Renewable and Sustainable Energy Reviews 31 (2014) 312–318

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Critical review of the current status of wind energy in Thailand

Sakkarin Chingulpitak, Somchai Wongwises *

Fluid Mechanics, Thermal Engineering and Multiphase Flow Research Lab. (FUTURE), Department of Mechanical Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Bangmod, Bangkok 10140, Thailand

ARTICLE INFO

Article history:
Received 22 August 2012
Received in revised form
22 October 2013
Accepted 18 November 2013
Available online 18 December 2013

Keywords:
Wind energy
Wind energy potential
Wind farm
Electricity
Renewable energy
Thailand

ABSTRACT

Thailand generates electricity from many sources, including natural gas, coal/lignite, fuel oil, diesel, and renewable energies, such as wind, hydroelectricity, and solar power. In 2012, the main electrical energy sources in Thailand were natural gas (63.8%) and coal/lignite (27.7%). Due to fuel price spikes and global warming, several countries are now more interested in studying and developing sources of renewable energy.

Wind energy – an unlimited and environmentally friendly form of natural energy – has attracted increasing levels of investment, particularly in China, which derives more of its electricity from wind energy generation than any other country in the world. Thailand has also developed and promoted the use of wind turbines to generate electricity. In 2012, Thailand generated about 111.7 MW of electricity from wind energy. By 2021, the Thai government's goals are to increase the use of alternative electric energy to about 25% of fossil fuel use and to achieve 1800 MW of electricity output from wind energy.

This article will present a critical review of the current status of wind energy in Thailand, including future plans for using wind energy in place of fossil fuels – oil, natural gas, and coal – to generate electricity.

Contents

1. Background

For past several decades, energy has been an important, fundamental factor in daily life, business, and industry, including the transportation, manufacturing, and telecommunications sectors. For this reason, a reliable energy supply with sufficient quantity, good quality, and reasonable prices is vital. However, the unstable price of energy in the world market, especially the steadily increasing price of crude oil, has had a serious effect on the economies of several countries, particularly those that must import significant quantities of oil. Furthermore, the use of fossil fuels also contributes to the problem of global warming. As a result, several countries have supported the use of renewable energy to promote energy security and environmental conservation. In 2012, China increased its wind-powered electricity generation and had the highest rate of wind-powered energy generation in the world. Thailand has also developed and promoted wind turbines to generate electricity because it is clean, eco-friendly, and cost-effective.

Abbreviations: AEDP, alternative energy development plan; GWh, gigawatt hour; GRP, glass-reinforced plastic; DEDE, department of alternative energy development and efficiency; EGAT, electricity generating authority of Thailand; EIA, environmental impact assessment; EPPO, energy policy and planning office; ktoe, kilotons of oil equivalent; kWh, kilowatt hour; PDP, Thailand power development plan; PEA, provincial electricity authority; SPPs and VSPPs, small and very small power producers, respectively; US$, US dollar (31.245 baht/US dollar foreign exchange rate, as of 13 August 2013)

* Corresponding author. Tel.: +66 2470 9115; fax: +66 2470 9111.
E-mail address: somchai.won@kmutt.ac.th (S. Wongwises).

1364-0321/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.rser.2013.11.038

This paper presents the current status of electricity generation and the proportion of electricity generated from renewable resources, especially wind energy. Wind energy potential is investigated and compared to other countries in Southeast Asia, including its obstacles to development and promotion, as well as future plans to use wind energy in Thailand.

2. Energy and electricity situations in Thailand

The final energy consumption of Thailand in 2012 was about 73,316 ktoe [1], an increase of 13% [2] from 2007. The total value of the final energy consumption was US$57,545.21 million. As shown in Fig. 1, petroleum products, renewable energy, electricity, coal/lignite, and natural gas represented 48.0%, 18.2%, 18.9%, 7.9%, and 7.0% of the total final energy consumption in 2012, respectively.

Considering the trends in primary energy supply (excluding energy exports) and final energy consumption from 2007 to 2012, as revealed in Fig. 2, it is observed that the primary energy supply increases year-by-year. In 2012, the amount of primary energy supplies was 130,848 ktoe [1]. For primary energy supplies classified by energy type, the highest share, which contributed 82.8% of the total primary energy supply, was from commercial energy (crude oil, lignite, natural gas, and so on), followed by renewable energy, biofuels (ethanol and biodiesel), and other forms of energy (black liquor and residual gas), at 16.2%, 0.8%, and 0.2%, respectively.

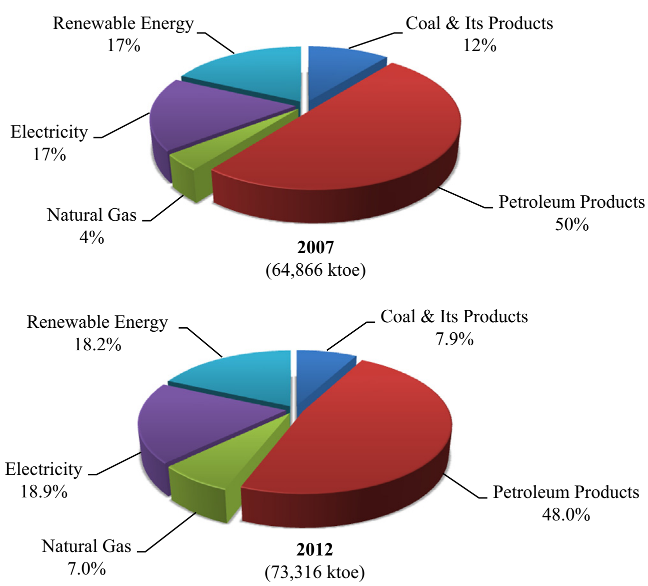


Fig. 1. Final energy consumption by types of Thailand for years 2007 [data from [2]] and 2012 [data from [1]].

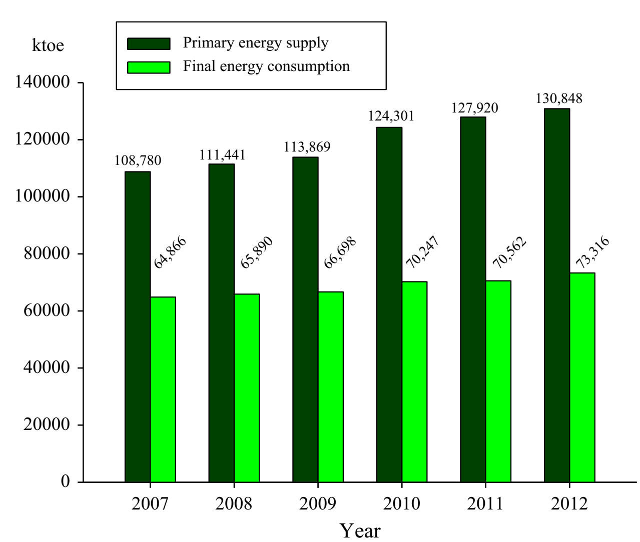


Fig. 2. Primary energy supply and final energy consumption from year 2007 until 2012 [data from [1] and [2]].

Thailand's electricity consumption was 162,668 GWh [1] in 2012. Most of this electrical energy, equal to 82,068 GWh, was consumed by the industrial sector. The commercial sector (including government, non-profit organizations, and street lighting), residential sector, agricultural sector, transportation sector, and other sectors (temporary customers) used 47,210 GWh, 32,097 GWh, 70 GWh, and 930 GWh, respectively.

Table 1 shows electricity generation, installation capacity, consumption, and electricity generation by energy source from 2007 to 2012, according to Thailand Energy Statistics 2012 [1] and 2007 [3]. There is a trend towards increased electricity generation every year. Thailand's electricity consumption in 2010 increased 10.4% from that of 2009, whereas it decreased by 0.4% in 2011, due to severe flooding by that year end. In 2012, Thailand's total electricity generation was 168,471 GWh [1], of which 63.8% was generated by natural gas, followed by coal/lignite (27.7%), and fuel oil and diesel (1.6%), with the balance being renewable energy and other types of energy (6.9%). From Table 1, it is clear that use of natural gas and renewable energy are increasing slightly. On the other hand, use of fuel oil for electricity generation has decreased significantly, due to an unexpected increase in oil prices; thus, promoting alternative energy to replace oil is necessary, especially alternative energy that can be produced in Thailand, such as biomass, biogas, solar energy, hydro energy, wind energy, garbage reclamation, and natural gas.

According to the CIA World Factbook, which lists all countries by electricity consumption, China had the highest electricity consumption, of 4,693,000 GWh [4], followed by the United States, the European Union, Japan, and Russia. Thailand's electricity consumption is rated twenty-fifth in the world and is the highest in Southeast Asia.

3. Wind energy potential in Thailand

Thailand is located near the equator and has low to moderate wind speeds that average about 3–5 m/s. A study of wind energy potential in Thailand began in 1975, when the Department of Energy Affairs of the National Energy Policy Office made a map of wind speed for use in planning, design, and installation of wind turbines. Average wind-speed data were supplied by the Thai Meteorological Department. Field studies then surveyed, measured, collected, and analyzed the wind-speed data. However, since there were several restrictions in making a map of wind-speed potential, the data are only available for low elevations.

In 2001, the map of wind-speed potential in Thailand was improved to include higher-elevation wind data in the analysis. The suitable areas that were selected have average wind speeds of not less than Class 3: 6.4–7.0 m/s or 300–400 kW/m^2 at an elevation of 50 m [5]. The existing data indicate that the coastal area of the Thai Gulf has the best wind energy potential in Thailand, followed by the upper southern region around the western coast of the Thai Gulf, which has an average annual wind speed of 4.4 m/s at an elevation of 50 m, as shown in Table 2 and Fig. 3.

In the same year, the World Bank proposed a wind energy resource atlas report for four countries in Southeast Asia: Cambodia, Laos, Thailand, and Vietnam [6]. As shown in Tables 3 and 4, the report uses simulations based on global winds to demonstrate which areas are best for the development of wind energy. Table 3

Table 1
Electricity generation, installation and consumption, and electricity generation by energy sources [data from [1] and [3]].

	2007	2008	2009	2010	2011	2012
Electric generation (GWh)[a]	143,378	147,427	148,390	159,518	155,986	168,471
Installed capacity (MW)[a]	28,285	30,508	30,607	31,485	31,773	33,177
Electric consumption (GWh)[a]	133,178	135,449	135,209	149,320	148,700	162,668
National grid generation (GWh)[a,b]	128,819	132,781	133,458	144,362	138,247	–
Natural gas	88,166	94,549	97,595	109,454	98,128	–
Coal and lignite	28,716	29,480	28,020	28,207	29,642	–
Hydro	8114	7113	7148	5537	8163	–
Fuel oil	3646	1454	604	997	1986	–
Diesel oil	174	180	79	159	319	–
Other[c]	3	5	12	8	9	–

[a] Excluding private generation for own use.
[b] Excluding generation from small and very small power producers (SPPs and VSPPs) generated from renewable and conventional energy.
[c] Including geothermal, solar cell and wind turbine, etc.

Table 2
Good wind energy sites from a map of wind energy potential [data from [5]].

Area	Province	Wind power classes	Height of 50 m	
			Wind speed (m/s)	Wind power (W/m^2)
1 Tai Rom Yen national park	Nakhon Sri Thammarat	6–7	8.00–11.90	600–2000
2 Khao Luang national park	Nakhon Sri Thammarat	6–7	8.00–11.90	600–2000
3 Khao Pu – Khao Ya national park	Pattalung	6–7	8.00–11.90	600–2000
4 Wang Chao national park	Tak	6	8.00–8.80	600–800
5 Doi Intanon national park	Chiang Mai	4	7.00–7.50	400–500
6 Kaeng Krung national park	Surat Thani	4–5	7.00–7.50	400–600
7 Khao Phanom Bencha	Krabi	6	8.00–8.80	600–800
8 Ranod district	Songkhla	4	7.00–7.50	400–500
9 Songkhla Lake	Songkhla	5–6	7.50–8.00	500–700
10 Laem Tachee	Pattani	4	7.00–7.50	400–500
11 Hua Sai district	Nakhon Sri Thammarat	3	6.40–7.00	300–400

presents the percentages of rural population in the areas of each country where small wind turbines can be used at 30 m. This was estimated by determining the number of villages and towns located within each wind resource class. The data show that more than 30% of the rural population of Vietnam live in areas with good wind resources, whereas only 13%, 9%, and 5% of the rural populations of Laos, Thailand and Cambodia, respectively, live in favorable areas. For large wind turbines, Table 4 shows the land area in each country and total wind energy potential based on each wind speed class at 65 m. It is clear that Vietnam has the opportunity to develop large-scale wind turbines because of its large resource potential, followed by Thailand, due to its moderate resource potential and well-developed energy infrastructure.

In 2008, wind measurement stations were set up in six provinces along the coast of Southern Thailand: Surat thani, Nakhon Si Thammarat, Songkhla, Krabi, Trang, and Satun. Sensors for measuring wind speed and direction were installed at heights of 20, 30, and 40 m [7]. During 2008, the wind statistics that were recorded were used to estimate wind speed at heights of 80, 90, and 100 m. Moreover, the observed wind climate was analyzed for the prediction of 15 km wind resources around the wind station by using WAsP 9.0, the Wind Atlas Analysis and Application Program. The results showed that the average annual wind speeds at heights of 80, 90, and 100 m were between 3.4 and 9.5 m/s. From economic analysis based on very small power producers (VSPP), the study found that wind farm power plants installing wind turbine generators (WTGs) of 1.0, 1.5, and 2.0 MW can generate about 1018, 1038, and 1148 MW of electricity from wind energy, respectively, in the long term.

To measure the potential of wind energy in the upper northern region [8], the wind speed and direction were measured and recorded at heights of 20, 30, and 40 m at Rompothai, Phatung, Norlae, Nonghoi, Monlan, and Killom stations from April 2007 to June 2009. Over the same period, wind speed and direction were recorded at heights of 20, 30, and 80 m at the Maehae station. The wind data recorded were analyzed with WAsP 9.1 to evaluate the potential for electricity generation. In the case of a potential wind farm using a 1 MW wind turbine at a height of 80 m, the total installed capacity of the wind turbines is 68 MW, or around 160 GWh/yr. Moreover, the results of the site survey showed that the suitable areas – Killom, Monlan, and Maehae – were ready to install wind farms with capacities of 1 MW and 3 MW (total capacities of 9 MW and 27 MW), which can produce approximately 18.7 and 44.9 GWh/yr of electricity, respectively.

4. Current status of wind energy in Thailand

Wind-powered electricity generation around the world has increased every year since 1996. In 2012, the global production of wind energy totaled 282,587 MW [9], an increase of 44,799 MW, or 19%, over 2011. Most of the increase occurred in the United States, which accounted for 29.3% of the global increase in wind-powered energy generation. As a result, China had the highest wind-powered energy generation (75,324 MW), followed by the United States (60,007 MW) and Germany (31,308 MW).

Wind-powered energy generation in Thailand began in 1983, when the electricity generating authority of Thailand (EGAT) installed six sets of small turbines for a pilot project at Laem Phromthep in Phuket Province. In 1992, EGAT installed two more turbines with a total capacity of 10 kW. After that, both government and private agencies – particularly educational institutions –

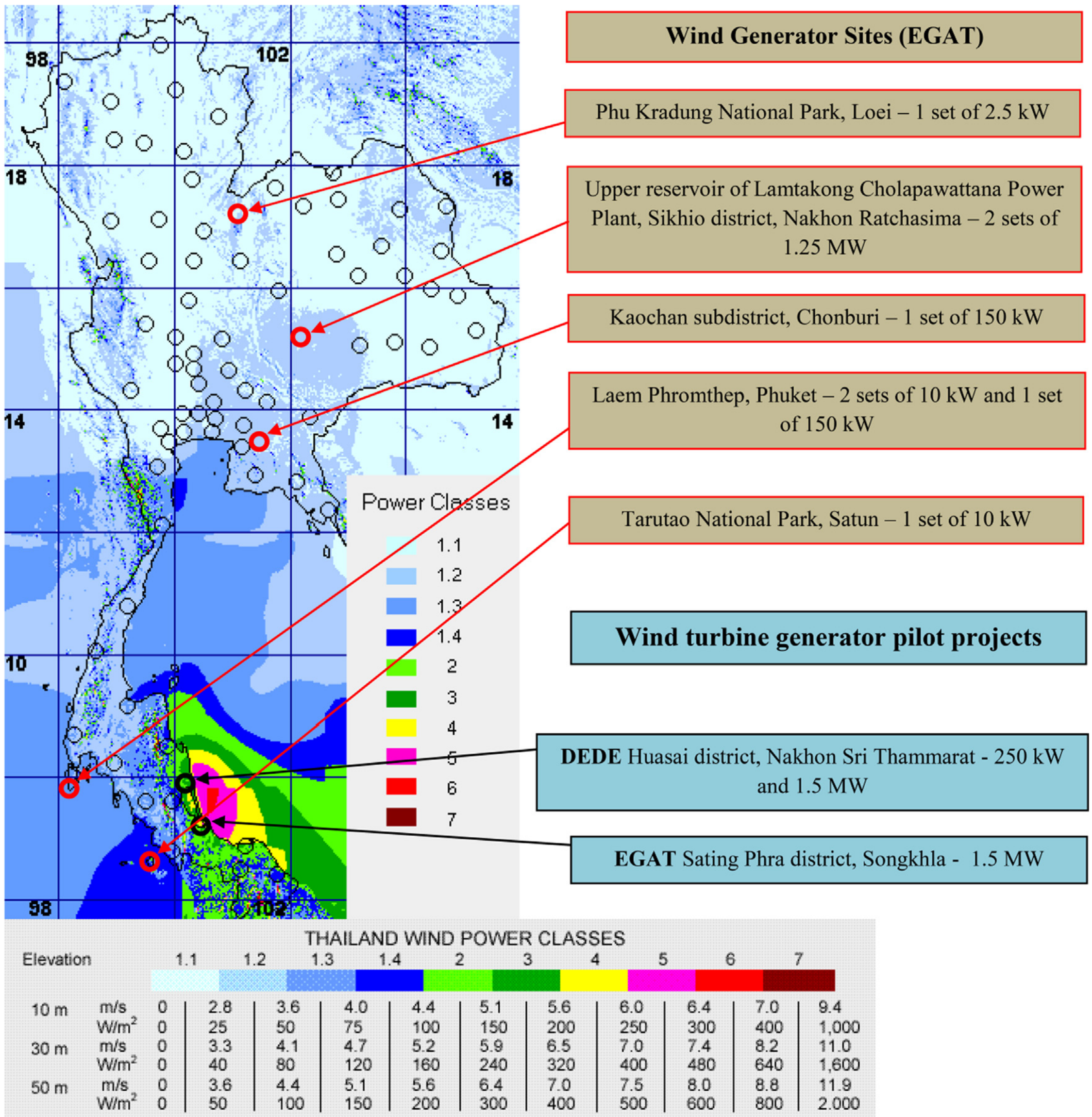


Fig. 3. Map of wind power potential in calm wind conditions – annual average [data and map from [5]].

Table 3
Proportion of rural population in each small wind turbine resource class[a] [data from [6]].

Country	*Poor (%) (<4 m/s)*	*Fair (%) (4–5 m/s)*	*Good (%) (5–6 m/s)*	*Very good (%) (6–7 m/s)*	*Excellent (%) (>7 m/s)*
Cambodia	15	79	5	1	0
Laos	55	32	13	0	0
Thailand	26	64	9	0	0
Vietnam	29	31	34	6	1

[a] Wind speeds are for cleared or open land with no obstructions at 30 m height. The proportion of rural population is estimated from the number of towns and villages in each wind resource class from the VMAP database (the US National Imagery and Mapping Agency Vector Map).

paid more attention to the study of wind energy for electricity generation. In 1996, King Mongkut's University of Technology/ Thonburi was the first to install 2.5 kW and 10 kW wind turbines at Phu Kradueng National Park, in Loei Province, and Tarutao National Park, in Satun Province, respectively. In the same year, the Recycle Engineering Company Limited installed one 150 kW wind turbine at Koh Chan Sub-district in Chonburi Province to generate electricity for use in buildings. As for government agencies, under the aegis of the Ministry of Energy, the Department of alternative energy development and efficiency (DEDE) installed one 250 kW turbine and one 1.5 MW turbine for electricity generation at Hua Sai District in Nakhon Si Thammarat Province in 2007 and 2009 [10], respectively.

The wind turbines were installed in 2009 by EGAT and connected to the electricity distribution system of the Provincial Electricity Authority (PEA). Two sets of 1.25 MW wind turbines – with a total capacity of 2.5 MW, which became the first large, wind-powered generation plant in Thailand – were installed at the upper reservoir of Lamtakong Cholapawattana Power Plant in Khlongphai Sub-district, Sikhio District, Nakhon Ratchasima [11]. The wind turbines that were used are Chinese-made D6-1250 models, which are three-blade horizontal-axis wind turbines with a pole height of 68 m and a blade diameter of 64 m. The blades are made of glass-reinforced plastic (GRP). The wind turbines turn automatically at wind speeds of 2.8 m/s or greater. The highest wind speed for electricity generation is 12.5 m/s. The turbines stop working when the wind speed reaches 23 m/s and stop generating electricity when the wind speed reaches 50.5 m/s [12].

Later, the provincial electricity authority (PEA) conducted a project to demonstrate the electricity generation from one 1.5 MW

Table 4
Wind energy potential of Southeast Asia at 65 m[a] [data from [6]].

Country	Characteristic	Poor (< 6 m/s)	Fair (6–7 m/s)	Good (7–8 m/s)	Very good (8–9 m/s)	Excellent (> 9 m/s)
Cambodia	Land area (sq km)	175,468	6155	315	30	0
	% of Total land area	96.4	3.4	0.2	0.0	0.0
	MW potential	NA	24,620	1260	120	0
Laos	Land area (sq km)	184,511	38,787	6070	671	35
	% of Total land area	80.2	16.9	2.6	0.3	0.0
	MW Potential	NA	155,148	24,280	2684	140
Thailand	Land area (sq km)	477,157	37,337	748	13	0
	% of Total land area	92.6	7.2	0.2	0.0	0.0
	MW potential	NA	149,348	2992	52	0
Vietnam	Land area (sq km)	197,342	100,361	25,679	2187	113
	% of Total land area	60.6	30.8	7.9	0.7	0.0
	MW potential	NA	401444	102716	8748	452

[a] Wind speeds are for 65 m height in the predominant land cover with no obstructions. For large wind turbines only. Potential MW estimates an average wind turbine density of 4 MW/km^2 and no exclusions for parks, urban, or inaccessible areas.

turbine at Sating Phra District in Songkhla Province [11]. The wind turbine used was a Chinese-made YFKF01-500/4 model and has the highest productivity in Thailand. The turbine has a horizontal axis driven by an asynchronous generator gear box, with a pole height of 80 m and a blade diameter of 77 m. Its three blades are made of GRP, with a total weight of 160 t. The turbine begins generating electricity at a wind speed of 3 m/s and reaches its maximum productivity at a wind speed of 11.5 m/s. The turbine can resist a maximum wind speed of 21 m/s [13].

The locations of the wind power plants in Thailand described above are shown in Fig. 3. It includes private generation for personal use, educational institutions, and commercial operations. However, in 2013, an updated map for the locations of wind power plants in Thailand was proposed [14], as shown in Fig. 4. It only presents the locations of wind power plants that generate electricity and supply it to the grid system, with a total capacity of 186 MW. The information of wind power plants that are being added are shown below.

The wind power plant “Chang-Hua-Mun” is located in Chang-Hua-Mun Royal Initiative Project, at Khao Krapuk Sub-district, Tha Yang District in Phetchaburi Province. His Majesty the King graciously observed that the landscape of the project area was suitable for the installation of wind turbines [15]. He graciously granted funds for the installation of 205 kW wind turbines (with a total capacity of 100 kW). The electricity used for the project was distributed to residents in the project area. Moreover, it was fed into the grid system of the Provincial Electricity Authority in 2009, with a capacity of 50 kW [15].

Later, the provincial electricity authority (PEA) installed one 250 kW wind turbine at Ko Tao, Ko Pha-ngan District in Surat Thani Province. A data collection and analysis during 2003 that assessed the wind energy potential found average wind speeds of 5.53 m/s. The wind turbine used is a Pioneer Wincon P250/29 model with a total capacity of 250 kW, or 10% of Ko Tao Island's total power consumption. The turbine (three blades) has a horizontal axis with a hub height 50 m and a blade length of 13.4 m. The turbine begins generating electricity at a wind speed of 3 m/s and cuts out at a wind speed of 25 m/s [16].

The “First Korat Wind” and “K.R. Two” projects for wind power generation were established by Wind Energy Holding Co., Ltd. at Huay Bong Sub-district, Dan Khun Tod District, Nakorn Ratchasima province in 2012 and 2013, respectively. The average wind speeds for both projects' areas are 6.2 m/s. In each project, 45 2.3 MW wind turbines (with a total capacity 90 MW) were installed, with a height of 99.5 m and a blade diameter of 101 m. These projects are the first large-scale wind farms in Thailand and have the highest capacity in Southeast Asia. Moreover, they are supported by governmental adder subsidies of about US$0.11/kWh over 10 yr [17].

5. Thailand's wind energy policy

Regarding the promotion and support for the use of renewable energy to generate electricity, the energy policy and planning office (EPPO) specified adder subsidies for several types of renewable energy. Therefore, small and very small power producers (SPPs and VSPPs) can sell their electricity to the electricity generating authority of Thailand (EGAT) or the provincial electricity authority (PEA) at higher-than-normal prices. Wind energy received adder subsidies of about US$0.08–0.11/kWh. The three southern provinces (Yala, Pattani, and Narathiwat) have special adder subsidies of US$0.16/kWh. This adder support lasts 10 yr, starting from the effective date of the contract [18–20].

Regarding the long-term 10-yr alternative energy development plan (AEDP 2012–2021), the Ministry of Energy aims to increase the ratio of alternative energy use to 25% [21] by 2021. Under this policy, renewable energy development projects will be initiated under the Thailand power development plan 2012–2030 (PDP2010: Revision 3) by the Energy Policy and Planning Office (EPPO). Therefore, in 2030, electricity generation from renewable energy will be 20,546.3 MW, or 29% of total electricity generation. Renewable energy sources can be classified into domestic renewable energy and renewable energy from neighboring countries, at 13,688 MW and 6,858 MW [22], respectively. Wind-powered electricity generation will be increased to a productivity of over 1800 MW. In 2012, Thailand had a wind-powered electricity generation of around 111.7 MW [23], as shown in Table 5.

Obstacles to development and promotion of wind energy in Thailand are as follows:

(1) Areas with high wind-energy potential are often located in mountainous or reserved forest areas; thus, private organizations that intend to invest in wind turbines (of more than 1400 MW) often face problems in getting permission to use the area from related governmental agencies. However, this obstacle can be resolved between private organizations and governmental agencies by allowing the installation of wind

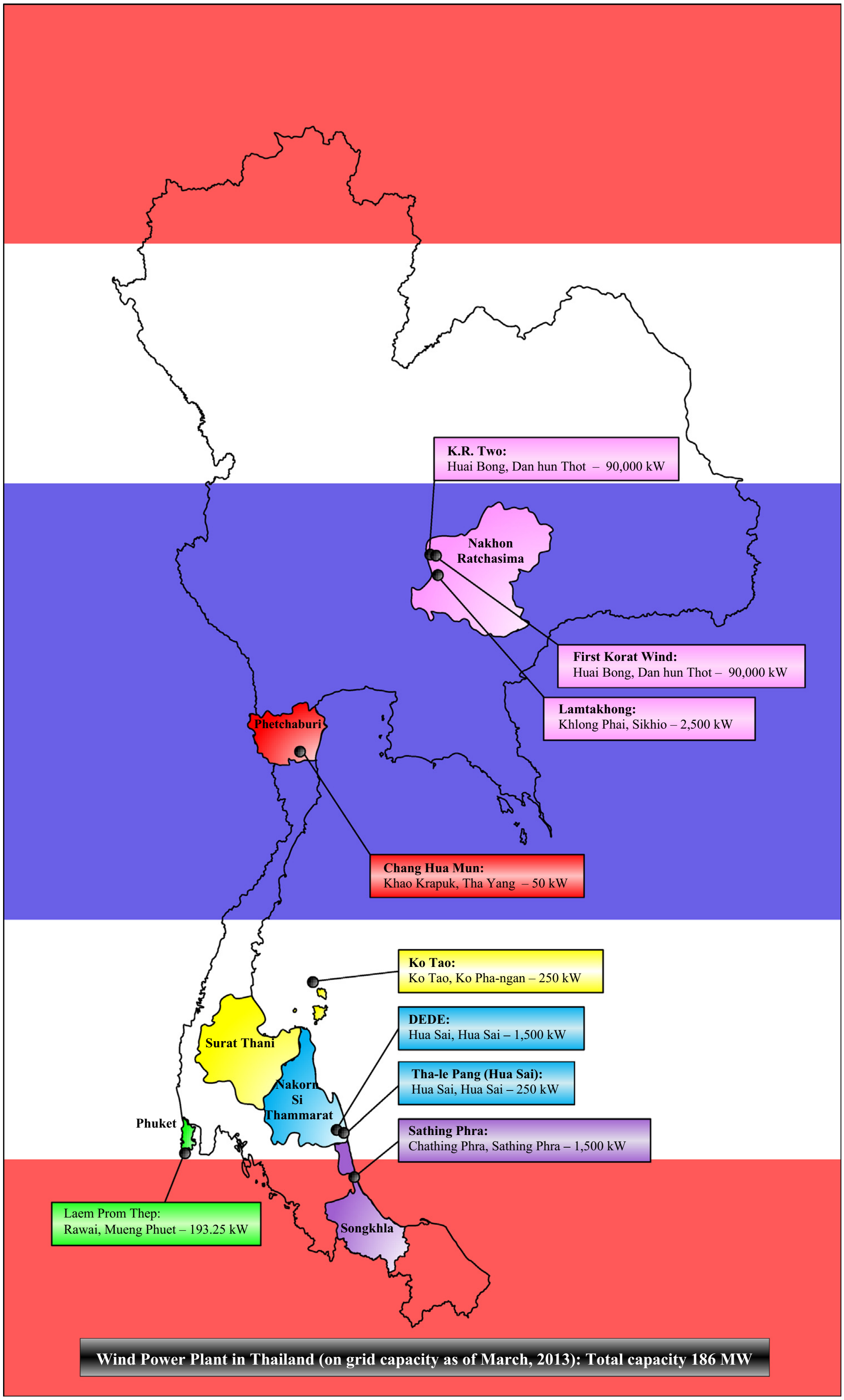


Fig. 4. Map of wind power plant in Thailand [data from [14]]

farms at rental rates of US$0.7/$m^2$/yr and project durations of no more than 27 yr [20].

(2) Some other problems are the cost of producing and installing wind turbines and the appropriateness of the site. There must be 22, 33, or 115 kV high-current electricity discharge systems within a 10 km radius of the area to connect with the electrical system of the provincial electricity authority (PEA). Because of this, the Thai government plans to improve its power

Table 5
Status and target for use of alternative energy in electricity generation [23].

Type of energy	Output in 2010 (MW)	Output in 2011 (MW)	Output in 2012 (MW)	Target in 2021 (MW)
Wind	*5.6*	*7.3*	*111.7*	*1800*
Solar	48.6	78.7	376.7	3000
Water	58.9	95.7	101.8	324
Biomass	1650.2	1790.2	1959.9	4800
Biogas	103.4	159.2	193.4	3600
Waste	13.1	25.5	42.7	400
New energy	–	–	–	3

infrastructure, including its grid and energy storage systems. In addition, the government has promoted the creation network of wind energy producers and users to facilitate wind energy connections in the future.

(3) There are also environmental problems, such as destruction of scenery, noise pollution, impact on creatures living within the installation area, and so on. To solve these problems, the environmental impact assessment (EIA) should be considered at the potentiality stage of a project.

6. Conclusions

Thailand's best wind-energy potential areas are around the coast of the Thai Gulf and higher-elevation lands, with average annual wind speeds of 6.4 m/s at an elevation of 50 m. Another potentially good area is around the western mountain ridgeline, from the lower northern to the upper southern part. The next-best potential areas, with average annual wind speeds of 4.4 m/s and higher at an elevation of 50 m, are the upper southern portion, the western coast of the Thai Gulf, the northern mountainous areas, the western coast of the south, and the eastern coast of the Thai Gulf.

Wind-powered electricity generation in Thailand has increased continuously in both the governmental and private sectors. In 2012, Thailand generated approximately 111.7 MW of electricity from wind energy. By 2021, Thailand aims to increase the ratio of wind energy use in electricity generation to a total productivity of 1800 MW, or 12.9% of all electricity generated from alternative energy in the country.

Acknowledgments

The authors are indebted to the Thailand Research Fund, the National Science and Technology Development Agency and the National Research University Project for supporting this study.

References

[1] Department of Alternative Energy Development and Efficiency. Ministry of energy, Thailand energy statistics (Preliminary), ⟨http://www.dede.go.th/dede/images/stories/stat_dede/report12/%202555_1.pdf⟩; 2012 [accessed 13.08.13].
[2] Department of Alternative Energy Development and Efficiency. Ministry of energy, Thailand energy statistics, ⟨http://www.dede.go.th/dede/images/stories/stat_dede/file_zip/Report%2011.rar⟩; 2011 [accessed 13.08.13].
[3] Department of Alternative Energy Development and Efficiency. Ministry of energy, electric power in Thailand: annual report, ⟨http://www.dede.go.th/dede/images/stories/stat_dede/electric54_1.pdf⟩; 2011 [accessed 13.08.13].
[4] Central Intelligence Agency (CIA). The World factbook, ⟨https://www.cia.gov/library/publications/the-world-factbook/rankorder/2042rank.html⟩ [accessed 18.04.12].
[5] Department of Energy Affairs. Wind resource assessment of Thailand, final report, central press, Thailand, ⟨http://www2.dede.go.th/dede/renew/Twm/MAIN.htm⟩; 2001 [accessed 19.08.13].
[6] The World Bank Asia Alternative Energy Program. Wind energy resource atlas of Southeast Asia; September 2001.
[7] Waewsak J, Kongruang C, Tirawanichakul Y, Tirawanichakul S, Matan N, Prompat C, et al. The potential of wind power along the coasts of southern Thailand. J Natl Res Counc Thail 2009:51–60 (Special Issue: 50th Anniversary).
[8] Dussadee N, Sasujit K, Suwannasit N, Kangvankij S, Suankamgong A, Kiatsiriroat T. Study on potential of power generation from wind energy in upper northern region. J Natl Res Counc Thail 2009:61–70 (Special Issue: 50th Anniversary).
[9] Global Wind Energy Council. Global wind report: annual market update, ⟨http://www.gwec.net/wp-content/uploads/2012/06/Annual_report_2012_LowRes.pdf⟩; 2012 [accessed 13.08.13].
[10] Ministry of Energy. Thai energy vision, public relations office; 2006. p. 214–31.
[11] Electricity Generating Authority of Thailand. EGAT and wind energy development for electricity generation, ⟨http://www3.egat.co.th/re/egat_wind/egat_wind.htm⟩ [accessed 17.08.13].
[12] Electricity Generating Authority of Thailand. Wind generator at Lamtakhong, Sikhio district, NakhonRatchasima, ⟨http://www3.egat.co.th/re/egat_wind/egat_windlamtakhong/wind_lamtakhong.htm⟩ [accessed 17.08.13].
[13] Sriwelaiwat T. The biggest wind turbine in Thailand, ⟨http://www.oknation.net/blog/nn1234/2010/06/04/entry-1⟩; September 28, 2009 [accessed 17.08.13].
[14] Department of Alternative Energy Development and Efficiency. Ministry of energy, map of wind power plant in Thailand, ⟨http://weben.dede.go.th/webmax/content/map-wind-power-plant-thailand⟩ [accessed 13.08.13].
[15] Provincial Electricity Authority. Electricity production from wind power project of "Chang-Hua-Mun" Royal Initiative Project, ⟨http://peas1.pea.co.th/bangsaphan/images/stories/PDF/wind%20power.pdf⟩ [accessed 23.08.13].
[16] Kitworawut P, Vathananukij H. Wind power: evolution Technology from the past to presence and futurity, ⟨http://gis.eng.ku.ac.th/Research/paper_wind%20energy.pdf⟩ [accessed 26.08.13].
[17] Wind Energy Holding Co., LTD. West Huay Bong 2 and West Huay Bong 3 Wind Farm projects, ⟨http://www.windenergyholding.co.th⟩ [accessed 23.08.13].
[18] Prapakdi S. Wind generator: environmental perspective. J Environ 2009;13:42–8.
[19] Energy Conservation Promotion Fund. Energy conservation plan and guidelines, criteria, conditions and priority of expense, ⟨http://www.eppo.go.th/encon/plan-2551-2554/encon-2551-2554.pdf⟩ [accessed 26.08.13].
[20] Ruangrong P. Thailand's approach to promoting clean energy in the electricity sector. Forum on clean energy, good governance and regulation: Singapore, ⟨http://electricitygovernance.wri.org/files/egi/Thailand.pdf⟩; 16–18 March 2008 [accessed 26.08.13].
[21] Department of Alternative Energy Development and Efficiency. Ministry of energy, the renewable and alternative energy plan for 25 percent in 10 years (AEDP 2012–2021), ⟨http://www.dede.go.th/dede/images/stories/dede_aedp_2012_2021.pdf⟩ [accessed 23.08.13].
[22] Energy Policy and Planning Office. Ministry of energy, summary of Thailand power development plan 2012–2030 (PDP2010: REVISION 3, June 2012), ⟨http://www.egat.co.th/en/images/about-egat/PDP2010-Rev3-Eng.pdf⟩ [accessed 20.08.13].
[23] Department of Alternative Energy Development and Efficiency. Ministry of energy, Thailand alternative energy situation, ⟨http://www.dede.go.th/dede/images/stories/stat_dede/Alternative_1012/thailand%20alternative%20energy%20situation%202012.pdf⟩; 2012 [accessed 20.08.13].